ELECTRONICS PERSONNEL RESEARCH

DEPARTMENT OF PSYCHOLOGY
UNIVERSITY OF SOUTHERN CALIFORNIA

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SHIPBOARD OBSERVATION OF ELECTRONICS PERSONNEL

A DESCRIPTION OF THE RESEARCH

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Principal Investigator

William W. Grings

Project Director

Glenn L. Bryan

Chief Observers

Donald W. Svenson
Harold R. LaPorte

Relief Observers

Joseph W. Rigney
Stanley Summers
John R. Hills

Data Analysts

William Axelrod
Nicholas A. Bond
Raymond M. Berger

DEPARTMENT OF PSYCHOLOGY

UNIVERSITY OF SOUTHERN CALIFORNIA

This report is one of a series based on shipboard observation of electronics personnel aboard ships of the destroyer class. The titles of these reports are given here along with a brief indication of the content of each. Security restrictions do not permit the general circulation of all of these reports but the accompanying list will help the reader place the present report in context.

1. Shipboard Observation of Electronics Personnel:
   A Description of the Research

   A general presentation of the problem, its background, and the observational techniques which were employed.

2. Shipboard Observation of Electronics Personnel:
   Detailed Descriptions of Observational Techniques.

   A report for the professional worker who desires precise detail regarding the forms and instructions used and the decisions underlying their selection. The summarized data are provided in a classified supplement.

3. Shipboard Observation of Electronics Personnel:
   Implications for the Training of Electronics Personnel.

   Various problems of training are formulated and related to the observational data.

4. Shipboard Observation of Electronics Personnel:
   Shipboard Activities of Electronics Technicians.

   Detailed accounts of the activities of electronics technicians are presented. Topics such as the materials, duties, problems, and future plans of the technicians are discussed.

5. Shipboard Observation of Electronics Personnel:
   Brief Descriptions of Related Electronics Jobs.

   The jobs of the Sonarman, Radarman, and Radioman are briefly described. The areas of overlap between these jobs and the job of the ET are discussed.

6. Shipboard Observation of Electronics Personnel:
   Implications for Certain Operational and Administrative Problems.

   Problems of Shipboard administration, policy, and the operational requirements of the electronics situation are related to the observational data.

7. Shipboard Observation of Electronics Personnel:
   General Conclusions and Recommendations for Further Research.

   The objectives of the research are reexamined and general con-

ods are presented.

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ABSTRACT

This report presents a non-technical account of a research program designed to investigate personnel problems associated with electronic maintenance and operation.

The procedures employed for obtaining objective descriptions aboard ships operating in the Pacific area and a description of groups observed are given.

Rationale underlying the development of a battery of observational techniques is presented, and each of the techniques is described in general terms.

A brief discussion of the treatment of the data is given, and evaluations of the methods are presented.

The paper is concluded with some general evaluative comments concerning the use of a multi-method approach.

A DESCRIPTION OF THE RESEARCH.

INTRODUCTION

The purpose of this report is to present a non-technical account of a program of research designed for making preliminary observations of the shipboard electronic situation with an emphasis on the maintenance aspects of the situation. The observational techniques used and the methodological problems involved are discussed. More technical treatments of this material and the results of the investigation are contained in other reports of this series.

STATEMENT OF THE PROBLEM AREA

The primary objective of the investigation was to obtain an accurate description of shipboard electronics. Such a description is essential to the eventual organization of the research area and it is prerequisite to the formulation of specific research hypotheses. In addition, the examination of such a broad area during the initial stages of a research effort yields important by-products. For one thing, the information derived is of immediate interest in its own right. While it does not provide answers to rigorous experimental questions, such a description of the shipboard electronic maintenance situation is of general value to those charged with the responsibility of providing trained men. A second important by-product of such research is the opportunity it provides for the try out of new research methods which may be adapted to later experimental efforts.

During the planning stages of this study a number of alternative approaches to the problem of developing detailed and accurate descriptions were considered. Pertinent written material was examined and evaluated as a source for describing the electronic maintenance activities performed by members of ships' crews. These sources did not provide the detailed description which was desired for this research. It was decided that the problem of fleet description could best be accomplished by more direct means.

Field work as an initial stage of a research program has the advantage of providing an opportunity for research personnel to live with the problems with which they are to work. Productive research insights are more likely to occur in this setting. Intimate acquaintance with the problem area is particularly valuable since the eventual decision as to the feasibility of shipboard research of various kinds can be determined only by those who have detailed knowledge of both the shipboard situation and the research potential of the group.

The decision to do field research was essentially one as to where the research was to be done. Once this judgment had been made, ways for accomplishing the research were considered. Three alternative approaches were examined and evaluated. They were unstructured observation, the application of a single observational technique, and the concurrent use of several different observational techniques.

Unstructured observation consists of observing without plan or limitation. The

principal advantage of such observation is that it does not commit the observer to a rigid schedule or a fixed procedure. He is left free to observe, directing his observation as he sees fit. During World War II the preliminary steps of Operations Analysis often took the form of trained observers "just looking" with the objective of discovering and gaining insight into the problems of an area in which they were relatively naive. Quite often such an observer would see a problem in a new way and in certain cases could suggest ingenious solutions to it. The success of such procedures is probably due to the detached objectivity of the observers, their freedom to observe, and their ability to transfer ideas and methods from old settings to new ones. The principal difficulty with the procedure is that there is no guarantee that an "open-eyed and open-minded" approach will be either efficient or effective.

The application of a single observational technique consists of applying a sel- technique (or a very small number of observational techniques) exclusively. This approach is particularly suited to those well-structured situations where problems have been carefully defined and reduced to testable form. Under these conditions it is most efficient and economical to devise a specific method for each specific problem. This approach, however, has an inherent difficulty. It is so selective of information that much of the data which would be pertinent to the broad understanding, appreciation, and organization of a domain is not collected.

The concurrent use of several different observational techniques is essentially an eclectic approach. It employs a battery of observational methods which complement one another in such a manner as to comprehensively cover the total domain being observed. The advantages of each method are capitalized upon while the weak points of each are overcome by the use of other methods.

The consideration of the three alternative approaches (namely: unstructured observation, the application of a single observational technique, and the concurrent use of several different techniques) led to the decision to adopt the third alternative. This approach came to be known as the multi-method approach. It will be referred to in this manner throughout the series.

THE MULTI-METHOD APPROACH

A number of specific objectives for the multi-method approach were formulated. Many kinds of information were desired from various sources. The major effort was to obtain objective and unbiased descriptions of the jobs that electronic personnel perform. These descriptions were sought from three different sources: members of the research group who observed and reported the behavior of the men on the job; the men themselves; and the supervisors of the men. Each of the sources offered specific but differing advantages. The man's own account of his job could be quite detailed but it could be distorted by such factors as the personality of the man and his lack of objectivity. The observers' account of the man's activity was more objective but limited by time and situational factors. The supervisors' descriptions were subject to still another set of biases. Since each source of description presented a slightly different picture, a composite of the three was used to uncover the many different facets of the situation. Techniques were introduced for the purpose of obtaining descriptions of the men who made up the sample. These techniques sought relevant facts concerning the present status of the men, their past history (e.g., time in the service, past assignments, and previous training), and their future plans. Descriptions of the jobs and descriptions of the men were complemented by descriptions of the physical plant, available tools, test equipment, stowage facilities, and records.

In addition to various descriptions, the battery included methods which required certain judgments. Electronic maintenance personnel judged the relevance of certain training topics and exercises to the maintenance man's job. These men also judged the degree of skill and the amount of electronics comprehension required to do a certain task. The officers who were in charge of the different groups of electronics personnel judged the importance of a number of specific abilities to the proficiency with which the job was done. They also ranked the abilities from "most important to the job" through "least important to the job."

Certain key personnel were also asked to give their opinions regarding Navy problems. These opinions took the form of selecting which of several available solutions was "best." No attempt was made to determine the attitudes of the respondents or to assess their morale. It is important to keep in mind that this investigation was essentially non-evaluative throughout.

The multi-method battery covered one other area. Detailed accounts of specific past events were requested from some members of the sample for the purpose of extending the range of the observations beyond the temporal limitations imposed by the fact that the observers were aboard each ship for a week or less.

DEVELOPMENT OF INDIVIDUAL METHODS

The selection of methods to accomplish the objectives stated above was based upon a number of considerations. A method would be included only if it promised to contribute relevant information. Because of the descriptive nature of the approach, the limits of relevancy were broad. Items were included if the information was suspected to be relevant. The relationship between the methods was also considered. Methods which yielded duplicate information were eliminated unless part of their purpose was to provide a check upon the other methods. The more objective and reliable methods were selected. Proposed plans of analysis also governed the selection of the methods. Those methods which permitted the most straightforward analytical treatment were used whenever possible. In addition to these rather general considerations, there were certain criteria which served as limits in the choice of observational techniques. A method could not be used unless it was sufficiently portable to be carried aboard ship. Care was taken that the methods could be administered by one man within the situational limitations of a destroyer at sea. Time restrictions were taken into consideration, and each method had to be accomplished without interfering with the activities of shipboard personnel.

A number of different sources were used in the development of the subject matter of the various methods. Navy manuals, textbooks, and forms were of great assistance. Civilian textbooks in the areas of electronics and electricity provided many useful items. Research conducted for other branches of the armed services and for industry contributed to several of the methods. Much of the subject matter and a great deal of practical advice was obtained from conferences, interviews, and conversations with various Naval personnel.

Proposed observational methods were subjected to try outs of various sorts. The principal effort in this direction was to try out the method on board a destroyer that was undergoing a shakedown period. At the conclusion of each trip the method was evaluated in terms of: the form of analysis that was proposed for it; the relationship of the method in question to the other methods; administrative restrictions that were encountered during the try out trip; the reaction of the men; effort requirements; situational limitations;

sample used; recording problems encountered; time limitations; and potential sources of bias. Appropriate revisions were made and the method was taken to sea again. Methods were subjected to try out in the order in which they were completed with the result that some of the methods received more extensive pretesting than others.

In addition to the shipboard personnel, two other groups were employed from time to time to pretest the techniques. Personnel from the electronics training section of UWATE acted as subjects and offered helpful criticism of some of the methods. During the very early stages of the development of some of the methods college students who had served as electronics technicians during World War II served as subjects.

THE OBSERVATIONAL PROGRAM

Electronics personnel aboard twenty ships of the destroyer class made up the final observational sample. One of the reasons that ships of this class were chosen was that they were less specialized as to duty than many of the ships that were smaller or larger. This lack of specialization offered the maximum possibility of generalization of the data to ships of other types. Destroyers have every major class of electronic equipment, and they encounter most of the electronic problems that any class of ship might be expected to encounter. Another reason for selecting destroyers as the class of ship upon which the observations were made was the fact that a sufficient number of different ships of this type are available to permit the collection of the data within practical time limitations.

Administrative arrangements for the observational tours were made in cooperation with the office of the Commander of the Cruiser-Destroyer Force of the Pacific Fleet. The ships were notified of the observers' arrival about one day in advance.

The observations took place while the ships were engaged in training operations at sea. These operations were of the usual type and included almost all of the different destroyer missions with the exception of shore bombardment.

Each observational team was composed of two members. The decision to use a team of this size was a result of the try out trips which revealed that a single observer would not be able to accomplish the observational mission within the allotted time and that shipboard facilities were too limited to accomodate larger groups.

Trips varied in length from 2½ days to 5½ days with an average of about four days per trip. Usually the ships steamed at night, but in some cases they anchored or returned to harbor. On a typical trip the observers would board the vessel on Sunday evening, and the ship would get under way early on Monday morning. Throughout the trip the observers worked independently except that they coordinated their activities so as to prevent duplication of effort and unintentional omission of data. The early portion of the trip was spent acquainting the officers with the purpose of the observations and enlisting their cooperation. The remaining time was spent participating in the ship's exercises as an observer.

Efforts were made to ensure standard observational procedures during the course of the study. The observers received training on how to employ the various methods. This training period included orientation trips and sea-going try outs with the methods. Another means of maintaining standard procedures was to rotate the observers so that no two observers consistently worked together. This process of rotation allowed the project director to ride as an observer with each of the other observers and thus dis-

cover and correct any deviation from standard practice. A third means of minimizing the variance between observers was the use of an observer's manual. This manual gave "cookbook" instructions as to exactly how each of the methods should be used.

Although it was desirable to cover the entire area of electronics, it became apparent quite early in the planning of the study that certain concessions had to be made to reduce the domain to a workable size. One of the most important of these was to give up the idea of making a complete and comprehensive description of both the operating and maintenance aspects of electronics activities. The attention of this study came to be focused on maintenance. The maintenance data are, therefore, more detailed and voluminous than the non-maintenance data.

The sample of shipboard electronics personnel was further restricted because of other considerations. Some methods could not be used as widely as they might have been due to their time consuming nature. This was particularly true of the interview which might have been used more extensively if each had not required approximately an hour of the observer's time. The same time limitation led to the restriction of the card sort sample. Each sorting took so long that it was not feasible to have all of the radarmen and the radiomen participate. As a result, only the leading petty officer for each of these ratings attempted the card sort.

Opinions were sought from those members of the sample who were in such a position that the particular opinion held could influence policy. For this reason, most of the sample for the general questionnaire was made up of officers. The samples for certain other techniques were limited to persons in supervisory positions. A detailed summary of the sub-samples to whom the various methods were administered is included at the end of the next section of this report.

DESCRIPTION OF METHODS

A form of diary keeping was introduced into the methodology as a means of recording direct observations of the men, their jobs, and the gear. The diary was essentially a technique in which the observer recorded in a time sequence all that took place within a predetermined area of observation. Observations were recorded either in writing or on a tape recorder. The diary accounts were oriented about the man-on-the-job, the electronic equipment, and the trouble shooting situation. The man-oriented diaries required that the observer accompany a man and observe everything that he did in a given period of time. For the place-oriented approach the observer took a position in an area where electronic equipment was installed and recorded the activities of the men in that area during a specified time interval. Examples of such "places" are CIC, radio central, transmitter room, etc. Emphasis was placed on trouble-oriented diaries. Whenever word was received of an electronic failure, an observer would go to the scene of the repair and record in detail an account of the trouble shooting activity until the equipment was again operating.

Another method, a check list, was used for the recording of direct observations by the observer and for securing descriptions by supervisors of the work done by the men under their supervision. Statements for the check list were chosen to match the generality level of standard Navy job description materials used in the fleet, such as the Manual of Qualifications for Advancement in Rating. The job statements were checked according to the rate of the man observed and the class of equipment involved.

With regard to the manipulation of various electronic equipment, terms such as "calibrates," "operates," "measures sensitivity of," "does preventive maintenance upon"

and "trains personnel performing corrective maintenance on," are typical of the list. Further emphasis was placed on the use of test equipment. Items not related to specific equipment were also included. Examples of these are "orders replacement parts," "maintains records of electronic equipment," and "refers to circuit wiring diagrams."

When the check list was used for direct observations, the observer checked the appropriate job statements while watching the worker perform a given task. As an indirect observational technique, the check list was filled out by the leading petty officer. He used his knowledge of the activities of his men as a basis for his checks. Enlisted supervisors were used for radarmen, radiomen, sonarmen, electronics technicians, and fire control technicians. The only officer called upon to complete a check list was the electronics repair officer.

In an effort to get judgments of the importance of certain abilities to given jobs, a rating scale was constructed for use by supervisors. It was called an ability requirements scale and its use was intended to be exploratory. The scale consists of nineteen items which endeavored to describe independent and non-overlapping ability traits. The items were designed to capture in a single statement the central meaning of a trait which had previously been defined by factor analysis. Examples of these trait designations are "ability to do arithmetic problems, such as adding, subtracting, multiplying, and dividing"; "ability to put practical problems into mathematical terms so that they can be solved"; "ability to lay plans and foresee problems"; and "ability to solve problems involving mechanical things such as gears, levers, etc."

Each trait was evaluated in two ways: (1) on a five-point scale indicating the relative amount of the particular ability required for the job, and (2) by a rank ordering of all traits. The job of the electronics technician was evaluated by the lead ET and the electronics officers, the radarman's job by the CIC officer, the sonarman's billet by the ASW officer, the radioman's job by the communications officer, and the work of the fire control technician by the assistant gunnery officer in charge of fire control equipment.

A job questionnaire was included among the methods to take advantage of the simple and economical means for obtaining job information which the questionnaire approach provides. In addition to descriptions of pertinent duties, it contained questions covering materials used on the job and items relating to the personal history of the man questioned.

Examples of the biographical data items are:

"How long have you been on this ship?"

"What job titles did you hold before being assigned your present job title?"

"List the names and locations of Navy schools you have attended and indicate the time spent in each."

Job description items ranged from:

"Check as many of the following publications as you use in your work on this ship."

"Check below each of the pieces of test equipment you have used in your work on this ship."

to.

"List, if possible, at least five duties which you perform when at your battle station and after each of these duties estimate the percentage of time you spend while at battle station doing this duty. The sum of all of these percentages should equal 100 per cent."

These questionnaires were completed by all enlisted electronics personnel on the ships. The forms were usually distributed by supervisors and collected by them when completed.

Officers, through an expression of their opinions on crucial matters, can contribute much information regarding the relative importance of certain personnel factors. To get the reactions of officers in the area of electronics, a general questionnaire was introduced.

Opinions were sought regarding the classification and utilization of personnel. For example, one item asked what per cent of the preventive maintenance work on radars should be done by radarmen and what per cent by electronics technicians. Another question asked what the electronics technicians should do when all of the gear was working. Still other questions related to matters of training, use of publications and records, and causes of excessive shut-down time. In all cases, items were written to receive definitive answers. They were predominately of the yes - no, multiple choice, or ranked alternative type.

In general the judgments were made by the officer about the situation faced by the men under him. That is, the CIC officer expressed his opinion chiefly with reference to the CIC situation, the ASW officer with reference to sonar, the gunnery officer with reference to fire control, etc. In this way, CIC, ASW, electronics repair, communications, gunnery, engineering, and operations personnel were represented.

The critical incident technique was employed to get anecdotal data on several questions for which this technique is particularly adapted. Some of these questions concerned: personnel factors which contributed to equipment malfunction, causes of excessive shut-down time, limitations placed upon maintenance activities by equipment design, and critical job requirements for electronics personnel. Other questions sought descriptions of incidents which were "typical" of unusually successful maintenance behavior and situations where electronics technicians were instrumental in the repair of sonar and fire control equipment.

Seven questions were used, each structured along the lines of one of the issues above. These were asked in a private interview situation with each electronics technician. A typical question was, "There are occasions when the repair of electronics gear is not accomplished as quickly as it might be. Can you tell me about a particular incident where a piece of gear was shut down for a longer time than it should have been?" The entire interview was tape recorded, and the incidents were later transcribed for analysis.

The training questionnaire was developed to collect the judgments of electronics technicians about the importance of selected training curriculum topics to their maintenance job. This consisted of a list of 211 standard curriculum topics, each of which the man on the job evaluated as to its usefulness in his assigned job. Topics to be rated were selected from the subject matters of basic electricity and electronics, and the principles of radio and radar. Items were divided between theoretical and performance types. Examples of theoretical items are "principles of regenerative and degenerative feed-back" and "characteristics of series-resonant circuits." Typical performance items are "perform familiarization exercises on oscilloscope" and "plot selectivity curves of receivers." Ratings were on a five point scale extending from "absolutely essential to job proficiency" to "of no value to job proficiency." Electronics technicians were the

only persons from whom this information was received.

One of the least conventional methods used a card sort. It was introduced in an attempt to get the men to describe their job in a common or uniform language by presenting to them a large number of job activity statements printed on cards and having them select those activities which they do as part of their job. In addition, it was possible to have the men make judgments about the job statements (such as the amount of electronics comprehension which each activity required) by sorting them into structured categories.

A deck of 247 cards was used. The face of each contained a statement which described a certain type of behavior which might be relevant to the duty assignments of the various men. Items such as "synchronize PPI sweeps" "manually tune cavity resonator" and "match impedance in double slug transmission line" are typical. All electronics technicians sorted the items according to relevance to their job, frequency of performance, where they first learned to perform the activity, and the amounts of electronics comprehension and skill required in performing the activity. Rated sonarmen and the lead radarman, lead radioman, and the fire control technician completed all of the above except the comprehension and skill sorts.

Each observer kept a written narrative account of each trip. This account was called the observer's log, or sometimes the log method, although it was not primarily a research device. The content of each log was determined by the particular observer. He was encouraged, however, to include all information of value which was not collected in some other manner.

The log served as a means of communication between the observers in the field and the other members of the research group. It was also a handy instrument for recording research ideas that occured to the investigator in the course of his observations. Frequently a casual conversation would be quite pertinent to the research, and in these cases the observer would include an abstract of the conversation in his log.

Repair records maintained by electronics technicians provide a potential source of information on such problems as causes of electronic failure, types of maintenance activities, equipment on which time is spent, and characteristic problems of given equipment. To collect this information for later analysis a record summary form was used. Repair data were copied from the shipboard records (usually equipment logs and repair record notebooks) to cover the period of the last complete calendar month. Information recorded included the date of the repair, equipment unit involved, nature of trouble and location, work done, parts used, operator on equipment when it broke down, and the rate of the person who made the repair.

To provide a more complete record for the period that observers were aboard, the electronics technicians were asked to complete a repair record on their next corrective maintenance operation. This record was more detailed than those usually kept by the men. In addition to the conventional items on equipment, nature of trouble, and parts used (as described above) this form requested information on all circuits tested, all parts tested, front panel indications of trouble, test equipment, tools and instruction books used, etc., plus a step by step description of work done from the time of notification of trouble until the repair was completed. The step by step description included outside interferences encountered, non-maintenance activities performed, and aid or supervision received, as well as tests and adjustments made.

Since there is some information which is difficult to collect with written and more formalized methods, an interview was scheduled with each electronics technician and the CIC and electronics repair officers. In most instances the answers to specific

questions were obtained, although the person interviewed was encouraged to expand on any point he desired. In the case of the electronics technicians the questions centered around such matters as motivation, future plans, and job preferences. Officers were asked about their primary and secondary duties, the degrees to which they encouraged specialization by their men, some of the interrelationships between officer responsibilities, and similar questions. About one half hour was devoted to the discussion of these matters, and a recording on magnetic tape was kept of the conversation.

All electronics technicians were administered the job questionnaire, the general questionnaire, the training questionnaire, and the card sort. In addition they filled out repair records, were interviewed, and provided critical incidents. The lead ET also completed the check list and the ability requirements scale. All sonarmen completed the job questionnaire. Rated sonarmen performed the card sort, and the lead SC filled out the check list. All radarmen and radiomen completed the job questionnaire, and the leads of each group prepared the check list and performed the card sort. The fire control technician completed the job questionnaire, check list, and card sort.

Officers who had electronics specialists directly under their supervision completed the general questionnaire and the ability requirements scale. This group included the CIC, ASW, communications, gunnery, and electronics repair officers (the latter also completing a job questionnaire and check list. In addition, the CIC and electronics officer were interviewed. The operations, engineering, and executive officers (and in most instances the commanding officer) were invited to complete the general questionnaire.

When the observer was not administering the card sort, interviewing, or helping men complete the questionnaires, he spent his time taking man-, place-, and trouble-oriented diaries. When word of equipment failure was received, he would leave whatever he was doing to go to observe the trouble shooting. He carried a check list with him at all times, making entries upon it as he observed men performing the activities listed. Every few hours he would make the necessary additions to his personal log to keep that record complete.

TREATMENT OF DATA

The analysis of the data was simple and straightforward. Its form was largely determined by the limitations of the sample and the objectives of the research. The data were treated in a number of different ways. The most often used form of analysis was the simple frequency count. This operation was employed extensively to answer such questions as, "How many men of a given rate lubricate PPI slip rings as a part of their normal job?" "How many men answered 'yes' to a given question?" and "On how many ships was such and such the case?" Percentages were computed in many cases to permit a comparison of the agreements and disagreements between the various rates and ratings. The use of percentages was required because of the highly variable number of cases in each of the sub-samples. Ranking procedures were introduced in order to indicate the most frequently used tools, publications, and job activities. Individual rankings were in many instances converted into rankings representative of the group. The desire to present the information as characteristic of a given group led to the computation of conventional expressions of central tendency and related measures of dispersion. The basic treatment of the critical incident data consisted of a logical organization of the key behaviors in each incident into mutually exclusive categories.

EVALUATION OF THE METHODS

In the light of experience in the fleet it is possible to evaluate the methods with regard to the extent to which each contributed the information for which it was designed. A rough division of the methods into three classes can be made, and the factors contributing to the evaluation discussed. These classes would be (1) the methods which lived up to all expectations, (2) those which were limited but not seriously, and (3) techniques which failed in some way to meet desired requirements.

The card sort and all of the questionnaire methods proved very satisfactory for their purpose. The card sort was well accepted by the men with the result that their motivation was easily sustained. The information gained was objective and capable of many possible forms of analysis. Its chief limitation turned out to be the amount of observer time that was required for its administration. Twenty to twenty-five hours were required per ship for this purpose. All of the questionnaires shared the advantage of ease of administration and made possible the collection of a maximum amount of information without interfering with shipboard activities. Because most of the questions were worded to yield objective answers, analysis of the data received was facilitated. The only difficulty encountered was the tendency of the men to confer about their answers, though they had been requested to work independently. Questionnaires, of course, could readily be used without requiring the observers to travel aboard the ships.

The period of four or five days for observation on each ship imposed limitations on the "opportunity to observe" for the methods requiring direct observation such as the diary and the observer completed check list. There were situations where no trouble-oriented diaries were taken during an entire week of operations because no trouble developed. In this situation, the observers' check list is very sparsely checked. There is little that can be done to overcome these obstacles except to extend the period of observation. It is important, therefore, that the sample of situations observed satisfy the criterion of representativeness. The check list was not subject to these limitations when filled out by supervisors.

Perhaps as much as any other method, the critical incident interview demonstrated the need for careful pretesting of questions and training of interviewers. In the case of one of the questions it was quite difficult to elicit descriptions of particular situations. Difficulty was also encountered in obtaining as many as four different incidents from the same man with reference to the same question. In addition, care had to be taken to keep from getting superficial or "generalized" incidents. When these problems were carefully attended to, the critical incident interview proved a fruitful source of information.

The general interview did not prove maximally successful for two reasons. In the first place it was greatly influenced by limitations of space in which to carry it out. Second, and more important, was the lack of sufficient structuring of the interview. Early in the study an effort was made to accent informality, open-ended questions, and a non-directive approach. This did not prove satisfactory, and it was later concluded that to be maximally useful under the circumstances, the interview should be highly structured.

The record summary was limited by the lack of uniform data. There was so much variation in record keeping practices from ship to ship that the data obtained from that source was highly variable.

In summary: the card sort, job questionnaire, general questionnaire, and training questionnaire were found to be the most efficient methods in the sense of providing the information for which they were designed. The diary, check list, critical incident, repair records, and ability requirements scale encountered occasional, but not serious, limitations. The interview showed need for revision, and the record summary was of limited usefulness.

EVALUATION OF THE MULTI-METHOD APPROACH

At the conclusion of such an observational effort as the one undertaken here it should be possible to evaluate the program as a whole. One might legitimately ask the question, "Did the multi-method approach come up to expectations, and if not, how did it fall short?"

Perhaps the most important objection to this approach is that it overloaded the observers. With twelve different methods to be accomplished, the observer had too little time to make the unstructured observations which were originally intended to occupy a central position in the study. If some form of full scale dress rehearsal had been used, this difficulty would have become apparent and could have been corrected in advance.

A second difficulty that arose from the use of more than one method stemmed from the fact that the various methods were so different in their administration and types of response. As a result, the individual observers tended to "push" certain methods on short cruises. Many factors went into the decisions that were made by the observers, but the overall effect was that the structured methods such as the questionnaires were completed early in the trip, while the unstructured observations were deferred to the end of the trip. Dress rehearsals probably would have helped this point also.

Despite the difficulties indicated above the multi-method approach was generally satisfactory. It provided a many-sided picture of an extremely inter-dependent and complex domain. The concurrent use of the several techniques permitted the comparison and tentative evaluation of a number of potential research methods. This was largely due to the fact that the methods were applied to a single captive sample. Most important of all, the multi-method approach yielded a set of descriptions which were broad in scope yet rich in detail.